

CALIFORNIA  
ENERGY  
COMMISSION

**PUBLIC INTEREST ENERGY  
RESEARCH PROGRAM,  
NATURAL GAS**

**PROPOSED Program Plan and  
Funding Request for 2006**

**Commission Report**

CEC-500-2005-133-CMF  
AUGUST 31, 2005



Arnold Schwarzenegger, *Governor*

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# EXECUTIVE SUMMARY

The California Public Utilities Commission (CPUC), in Decision 04-08-010, has designated the California Energy Commission as Administrator of the Public Interest Energy Research – Natural Gas (PIERNG) Program. This report complies with the requirements of the Decision and defines the second year (Calendar Year 2006) plan and budget for research and development activities to provide benefits for California's natural gas ratepayers. It establishes a set of Program Research Areas and Initiatives that constitute a \$15 million R&D effort for 2006.

Public purpose gas R&D activities are directed towards developing science or technology, the benefits of which accrue to California citizens and which are not adequately addressed by competitive or regulated entities. The Energy Commission has gathered input from its own energy and environmental R&D experts, interested parties, research groups, and the State's investor-owned gas utilities to define this R&D Program. The resulting Research Areas are (1) end-use efficiency, (2) environmental implications of natural use, (3) transportation, (4) renewables, (5) strategic analyses and (6) advanced generation.

The Energy Commission, as the PIERNG program administrator, is seeking approval for a 2006 Program year budget. This includes multi-year funding for projects that will be initiated in 2006 and program administration costs for 2006. Table ES1 on page vi summarizes recommended and prioritized Program Research Areas with an associated budget request for 2006. With the CPUC's approval, this Program will begin on January 1, 2006.

As noted in the State's 2003 Energy Action Plan, California's economic prosperity and quality of life are reliant upon dependable, high quality, and reasonably priced energy. Furthermore, as the CPUC stated in Decision 04-08-010, gas is a vital resource in the economic future of California. Since the CPUC's Decision, events have emphasized the importance of addressing natural gas research questions in California. In particular, rising gas costs, increasing interest in resource adequacy, bringing LNG into the State, and mitigating the effects of climate change are driving the focus of natural gas public interest research.

These events and interests are addressed within California's natural gas policy objectives. These policy objectives include promoting efficiency, promoting renewables, improving markets, improving natural gas infrastructure (for example as related to LNG and natural gas storage), and reducing environmental impacts of natural gas production and use (both air quality and climate change). This plan provides for an R&D Program that fits within the context of these policies and supports natural gas as an important energy resource.

The 2006 research program will also build on the 2005 program activities and adjust for events that occur in 2005. As briefly described in this document, 2005 was the first year for the PIER-Natural Gas program and to date \$10.5 million worth of projects have been approved by the Energy Commission's Research, Development and Demonstration Committee. Final approval of all projects is expected by the first Energy Commission business meeting in November. Initiating projects was delayed in 2005 due to contracting issues; however, these have been resolved by the passage of AB 1732 which the Governor signed on July 21, 2005. Other Legislation, SB71 and SB76, affected the natural gas research program. SB 71 requires the Energy Commission to submit a five year strategic research plan to the Legislature by March 31, 2006. The five year plan will address both natural gas and electricity research. SB 76 requires the Energy Commission plan half of the gas research budget with the Air Resources Board, with up to one third of the funds being available for transportation energy-related research projects. The co-planning requirement has been met in the preparation of this document. The Energy Commission may request adjustments to the budget during the 2006 program year as appropriate transportation projects are identified by joint ARB/CEC planning, and in response to compelling changes in research needs.

This report is organized into the following Sections:

- Section 1 provides background and the California regulatory and policy context for the defined research program.
- Section 2 summarizes 2005 activities.
- Section 3 describes 2006 PIERNG program Research Areas and budgets.
- Section 4 provides an overview of implementation actions including a long-term planning process, research program integration, outreach activities, and program administration and contracting.

The Appendices list and provide (under separate cover) the abstracts received by the Energy Commission in response to its request to the public for gas R&D recommendations, and the list of projects funded in the 2005 program year.

Table ES1: 2006 Research Program and Funding Request Summary

Ranked Research Subject Areas – with Research Initiatives	Description of Subject Area	Budget Allocation Per Research Subject Area
1. Gas Efficiency <ul style="list-style-type: none"> <li>▪ Gas water heating technology</li> <li>▪ Gas space heating technology</li> <li>▪ Commercial food service technology</li> <li>▪ Industrial combustion efficiency</li> <li>▪ Industrial waste heat recovery</li> <li>▪ Gas appliance technology</li> <li>▪ Gas space cooling technology</li> <li>▪ Systems optimization research and planning</li> </ul>	This area focuses on improving the efficiency of gas consuming equipment and systems in the residential, commercial and industrial sectors.	\$3.0 million
2. Environmental <ul style="list-style-type: none"> <li>▪ Air quality impacts and mitigation strategies for combustion of alternative gas supplies (e.g. off-spec and LNG)</li> <li>▪ Climate change adaptation and mitigation-- issues and implications for the natural gas system</li> </ul>	This research will improve analytical capability for assessing potential criteria air pollutant (indoor and regional) and greenhouse gas impacts and mitigation strategies for traditional and non-traditional NG blends.	\$2.75 million
3. Transportation	Research initiatives to be developed 1 <sup>st</sup> quarter, '06.	\$3.0 million
4. Renewables <ul style="list-style-type: none"> <li>▪ Water heating alternatives</li> <li>▪ Process heating alternatives</li> <li>▪ Renewable natural gas fuel replacements</li> </ul>	This area focuses on developing and commercializing alternative fuel sources, particularly solar energy and biofuels.	\$1.5 million
5. Strategic Analyses <ul style="list-style-type: none"> <li>▪ Tool and model development to aid in targeting appropriate infrastructure improvements</li> <li>▪ Economic research to address State gas energy policy issues</li> <li>▪ Security related to catastrophic events</li> </ul>	This research addresses topics such as value of increased gas storage; impact on gas prices and reliability of various fuel specifications, including off-spec and LNG; market analysis, identifying real time slack capacity needed in pipelines and mitigating impact of catastrophic events (e.g., earthquakes and terrorism).	\$1.5 million
6. Advanced Generation <ul style="list-style-type: none"> <li>▪ Combined cooling, heating and power (CCHP)</li> <li>▪ Natural gas reformers for fuel cells, turbines, and reciprocating engines</li> </ul>	This research will improve the efficiency and reduce the emissions from natural gas used in commercial and industrial electricity generation, process heating and cooling.	\$0.75 million
Small Grant Program	Concept feasibility research across all '06 subject areas.	\$1.0 million
Administration	Includes planning, project selection, contracting, project management and reporting.	\$1.5 million
Total		\$15.0 million

# SECTION 1: NATURAL GAS RESEARCH WITHIN A STATE POLICY CONTEXT

## Regulatory Background

Assembly Bill 1002 (stats. 2000, Ch. 932)<sup>1</sup> granted the California Public Utilities Commission (CPUC) the authority and discretion to determine the appropriate funding levels for natural gas low-income, energy efficiency, and public interest R&D activities. On August 19, 2004 the CPUC adopted Decision 04-08-010 which established the level of funding for natural gas public interest R&D, identified the California Energy Commission as the administrator of the PIER Natural Gas (PIERNG) program, and established the administrator's responsibilities.

Recent legislation has added new responsibilities to the Energy Commission as administrator of the PIERNG. Senate Bill 71<sup>2</sup> requires the Energy Commission to submit a report on the long-term research priorities, program management and staffing for its research program to the Legislature by March 15, 2006. Senate Bill 76<sup>3</sup> requires the Energy Commission and the California Air Resources Board jointly develop a strategic research plan for one half of the PIERNG funds in any given program year. Also, SB 76 allows that up to one-third of the funds may be used for "transportation related public interest energy research and development provided the research provides natural gas ratepayer benefits..."

SB 76 will become effective January 1, 2006, but given the August 31, 2005 due date for the 2006 Program Plan, its mandates could not be fully addressed. However, in response to SB76 the Energy Commission has budgeted \$3 million towards transportation research. The allocation of these funds will be determined later this year and early in 2006. If the result of the joint research planning indicates that additional, or less, funds are appropriate for this research area, a budget re-allocation request for transportation research funding may be forwarded in the first quarter of 2006.

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<sup>1</sup> AB 1002 is codified in Public Utilities Code Sections 890 *et seq.*

<sup>2</sup> Signed by the Governor on July 19, 2005.

<sup>3</sup> Signed by the Governor on July 21, 2005.

## State Energy Policies and Research Goals

The Energy Commission and the California Public Utilities Commission<sup>4</sup> have been working together over the past several years to create and update a state "Energy Action Plan." The Energy Action Plan's (EAP) goal is to:

Ensure that adequate, reliable, and reasonably-priced electrical power *and natural gas supplies, including prudent reserves*, are achieved and provided through policies, strategies, and actions that are cost-effective and environmentally sound for California's consumers and taxpayers.<sup>5</sup>  
[emphasis added]

To specifically address the critical role of natural gas in California's energy infrastructure, the EAP adopted as one of its six essential actions the need to "ensure reliable supply of reasonably priced natural gas."<sup>6</sup> Concern over high natural gas prices led the EAP to focus on the need to improve the supply infrastructure of natural gas, including the ability to import liquefied natural gas, monitor potential market power abuses, and encourage electric and gas utilities to hedge their price risk.

The natural gas price and supply concerns articulated in the EAP are reflected in specific policy goals in the 2004 Update to the Integrated Energy Policy Report (IEPR). The 2004 IEPR presents the progress made in implementing four policies directed at resolving natural gas price and supply issues for California:

- Increase funding for natural gas efficiency programs.
- Encourage LNG facility construction on the West Coast.
- Ensure existing storage capacity is used appropriately.
- Initiate hearings to examine gas quality and gas gathering issues.

CPUC decision 04-08-010 also established goals for the natural gas R&D program. As a public interest research program, the CPUC found that the program should "include a focus on energy efficiency, renewable technologies, conservation and environmental issues, support of State energy policy, a reasonable probability of providing benefits to the general public, and opportunities for collaboration and co-funding opportunities with other entities."<sup>7</sup>

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<sup>4</sup> The California Consumer Power and Conservation Financing Authority also participated until 2004 when it was disbanded.

<sup>5</sup> State of California Energy Action Plan, adopted May 8, 2003, p. 2.

<sup>6</sup> *Ibid.*, p. 8.

<sup>7</sup> D.04-08-010, FOF 32.



A synopsis of the policy directions and goals from the EAP, the 2004 IEPR Update and the CPUC Decision yields the content of Table 1.1. Addressing these state energy policies, the Energy Commission established the following research subject areas for its 2005 Program: 1) Natural Gas End-use Energy Efficiency, 2) Renewable Energy Technologies, 3) Strategic Analysis, and 4) Environmental Impacts of Natural Gas Consumption.

Although the events of the past year have not significantly altered the PIERNG research priorities, there is a need to further refine those priorities to include additional concerns or address changing priorities. For example:

- Natural gas price increases are no longer a hypothetical risk.
- Greater reliance on natural gas-run plants has created a new summer peak for natural gas.
- Higher prices and supply uncertainty have led to even more interest in developing alternative supply sources for natural gas, especially liquefied natural gas (LNG).
- The Governor has established aggressive goals for reducing Greenhouse Gases (GHG).

These developments and issues suggest some additional research needs and changes in percent allocations for the 2006 research priorities. Therefore, the Energy Commission recommends that the 2006 PIERNG continue building its research portfolios using the California natural gas policy framework shown in Table 1.1.

Table 1.1: California Combined Natural Gas Energy Policies

California Natural Gas Energy Policies Developed from the EAP, 2004 IEPR and CPUC Decision 04-08-010	
1. Promote Energy Efficiency	
2. Promote Renewable Energy	
3. Improve Natural Gas Markets	
4. Improve Natural Gas Infrastructure in California	Encourage LNG
	Improve Natural Gas Storage and Deliverability
5. Reduce Environmental Impacts of Natural Gas Production and Use	Reduce Impacts on Air Quality
	Address Climate Change Impacts

Table 1.2 lists the research subject areas of the 2006 Program Plan (except Transportation) and the California natural gas energy policies they address. The Energy Commission has initiated a long-term strategic planning process for all of its research and development programs. One product from this effort will be a five-year strategic plan for public interest energy research in natural gas. Within the planning process, the Energy Commission will engage the ARB during 2005 and 2006 to identify the policy framework and long range research goals for transportation and non-transportation research, and comply with Article 901 (b) of SB 76. Results of this strategic planning could result in

modifying the 2006 Program budget to fund additional transportation research. In this event, an amended budget summary showing new research area budgets will be provided to the CPUC for approval during the first quarter of 2006.

Table 1.2: 2006 Plan Research Areas and Corresponding Natural Gas Policies

California Natural Gas Energy Policies	Promote Efficiency	Promote Renewables	Improve Markets	Improve Natural Gas Infrastructure in California		Reduce Environmental Impacts	
				Encourage LNG	Improve Storage	Improve Air Quality	Climate Change
2006 Natural Gas Research Subject Areas: *							
Natural Gas Energy Efficiency							
Natural Gas Environmental Impacts							
Renewable Energy Technologies							
Strategic Analysis							
Advanced Generation Technologies							
Shaded cells indicate research efforts expected to address the associated policy.							
*Transportation research policy links and research initiatives are expected to be defined in the first quarter of 2006.							

## **SECTION 2: 2005 PROGRAM YEAR ACTIVITIES**

### **2005 Program Start-up**

As of August 2005, the Energy Commission has made substantial progress in implementing the new PIER Natural Gas Program. Actions have included:

- Staffing the program
- Establishing research technical assistance support from University of California,
- Obtaining legislative relief to enable effective research contracting and administrative procedures for the new program

The timeframe for establishing the program was extremely short, as the CPUC Decision creating the program was approved August 14, 2004 with the 2005 Program Plan due October 31, 2004. The 2005 Program Plan was approved at the December 16, 2004 CPUC Business Meeting.

In addition to the short planning timeframe, program implementation was further delayed due to specialized administrative and contracting procedures being unavailable to the new program. These procedures are now available to the program with the passage and signing by the Governor of legislation (AB 1372, signed as urgency legislation on July 21, 2005).

Program implementation was also delayed while recruitments for five new civil service positions for the program were undertaken. These positions have now been filled.

#### **Hiring of Program Staff and Obtaining Research Technical Assistance**

The CPUC advanced administrative funds in the amount of \$200,000 to the California Energy Commission in 2004 to employ staff for the PIER Natural Gas Program. The Energy Commission subsequently initiated and received approval for a Budget Change Proposal (BCP) justifying five civil service staff positions for the new program. All five positions were filled during the first six months of the 2005 program year.

The Energy Commission's electricity research program (PIER) uses a technical assistance contract with the University of California to provide specific and timely expertise usually associated with specific technologies and not available within state civil service personnel classifications. This contract was amended and augmented with \$1.032 million of administrative funds from the 2005 Program Plan to provide similar assistance to the PIER Natural Gas Program. This contract is now being used to provide specialized assistance in proposal evaluations, research roadmap development, technology assessments and other critical tasks essential to the gas research program.

## **Contracting and Administrative Legislation**

When the Energy Commission was named as administrator, State Law did not contain the same expedited procurement and contracting provisions for the Natural Gas Public Interest Energy Research Program that are allowed in the PIER Electricity program. Consequently, the Energy Commission was slowed in its implementation of the natural gas program. Left unchanged, the current law would have required the Energy Commission to develop separate, less effective administrative and program procedures for the natural gas program.

In order to improve the administrative efficiency and the delivery of services to clients and customers, the Energy Commission wrote and found sponsorship for a bill that granted its electricity research program's limited administrative exemptions to the natural gas research program. Specifically, this bill provides benefits such as research continuity, cost savings, clear rights to intellectual property, and the ability to award grants. The bill (AB 1732) was signed into law on July 21, 2005 and took effect on that day.

## **Funding Research in 2005**

Typically, completing research program technology roadmaps requires from 12 to 24 months. Due to the short program implementation timeframe, projects had to be selected in absence of established roadmaps. Therefore, a "no-regrets" approach was used, whereby public interest research projects with near-term benefit potential were selected. Project funding in 2005 proceeded in three steps:

1. Evaluating and continuing regulated utility transition research projects,
2. Obligating (encumbering) program funds for natural gas research in addition to the utility transition projects and,
3. Re-directing budgeted research funds in order to fund critical, near-term research needs that address air quality issues of liquefied natural gas (LNG)

## **Continuation of Regulated Utility Public Purpose Research Projects ("Transition" Projects)**

During the development of the 2005 research plan it was identified that only Sempra Utilities had several research projects that it considered appropriate for continued funding during 2005. With regard to existing public purpose R&D being undertaken by California gas utilities, Decision 04-08-010 ruled as follows:

"The Decision instructs respondent utilities to end or transfer to the CEC public interest gas R&D programs by December 31, 2004. This Resolution both instructs Sempra to submit copies of all materials furnished to the Energy Division concerning transition projects to the CEC, and instructs the CEC to maintain the confidentiality of that disclosure."

In the 2005 Natural Gas Research Program Plan approved by the CPUC, the Energy Commission stated that one of three options could be used to fund the transition projects:

1. CPUC could delegate authority for funding or not funding these projects directly to the Energy Commission. The Energy Commission could then, as Administrator, decide which projects to fund and thus which portion, if any, of the \$12 (sic) million budget should be allocated to these utility transition projects. This is the Energy Commission's preferred option.
2. CPUC could select none, some, or all of these projects for continuation in 2005 and, as required, use a portion of the requested \$12 million to fund them during 2005.
3. CPUC could use Energy Commission input in making the utility transition project funding decision at a future date after approving the Research Program Plan.

The CPUC staff indicated that the Energy Commission should proceed with Option 1 for the projects that originated with Sempra. After evaluating the submitted projects, the Energy Commission recommended funding of the following four projects:

<b>1</b>	<b>Super Boiler</b>
Research Initiative Area:	Industrial Combustion Efficiency
Budget:	\$397,563
Contractor:	Gas Technology Institute
<i>Project Description:</i>	The objective of this project is to develop the next generation of boilers. The U.S. Department of Energy (DOE), in collaboration with the combustion and steam generation industries, has established an Industrial Vision and Roadmap that defines the Super Boiler development, a goal to be achieved over the next fifteen to twenty years. This 4-year project is the first phase of development that will produce a novel compact, high-efficiency (94%+) and ultra low emissions (NOx < 5 vppm) boiler product.

<b>2</b>	<b>Development &amp; Demonstration of Ultra- Low-NOx Burners</b>
Research Initiative Area:	Industrial Combustion Efficiency
Budget:	\$43,638
Contractor:	Gas Technology Institute
<i>Project Description:</i>	The objective is to develop a version of the Forced Internal Recirculation (FIR) burner to achieve NOx emissions below 5 vppm in package watertube boilers with firing capacities of 16.7 million Btu/h and larger. The specific goals are to build one 20-million-Btu/h and one 50-million-Btu/h prototype burner, demonstrate these burners at industrial host sites, and produce a commercialization plan.

<b>3</b>	<b>Power Generation Integrated Steam System</b>
Research Initiative Area:	Industrial Combustion Efficiency
Budget:	\$226,443
Contractor:	CMC-Engineering, Inc.
<i>Project Description:</i>	This project will integrate a low-cost, <5 ppm NOx, 80-kWe turbine-alternator provided by Bowman Power into a modified windbox of a <9-ppm NOx Coen burner assembly for a packaged CHP system. Capital cost savings in the power generator portion of the CHP will be achieved by removing the recuperator and simplifying other components of the conventional microturbine generators (MTG), coupled with enhanced heat recovery in the boiler. The turbo alternator will be fitted with a <5-ppm single-combustor silo to be developed and demonstrated based on low swirl injection (LSI) nozzle technology being demonstrated at Solar Turbines under a DOE program and with assistance from Bowman Power Systems in the UK. This new CHP assembly represents a novel and efficient departure from conventional modular-type CHP assemblies, which simply couple existing, off-the-shelf recuperated MTG cabinets with boilers and chillers. .

<b>4</b>	<b>Fuel Cell Demonstration</b>
Research Initiative Area:	Air quality impacts and mitigation strategies.
Budget:	\$50,000
Contractor:	Logan Energy Corp.
<i>Project Description:</i>	The purpose of this project is to maintain two (2) PEM fuel cells that were installed in San Diego, one as a component of a "sustainable communities" project and the second at a City of San Diego office complex. This work will help to bring the benefits of distributed generation technologies, particularly fuel cells, to the California consumer. The contractor is to install the unit, start -up and commission the fuel cell, furnish as-built plans, and provide one-year maintenance, service, and customer support.

## Research Projects Funded in 2005

Pending completion of technology roadmaps for the Research Subject Areas, projects were chosen in 2005 based on abstracts received, links to California natural gas policy, the expertise of Energy Commission research managers, and near-term benefit potential.

The 2005 Program Plan described research issues associated with each subject area. In turn, these research issues correlate to state the energy policies for natural gas shown in Section 1, Table 1.1. Table 2.1 maps the 2005 Program Plan research issues to state energy policies for natural gas. Each of the 19 projects selected under the 2005 Program

Plan addresses one or more research issues. A list of all projects funded appears in Appendix C. As the program builds its project portfolios within each research initiative area, additional research issues will be addressed. Table 2.2 links each of the 19 projects funded in 2005 to research issues addressed and to corresponding energy policy.

Projects selected under the 2005 Program Plan address near-term technical and policy issues. The projects also correlate well with policy priorities for natural gas and will provide advancements in gas energy efficiency, renewable technologies, helping supply diversity by encouraging LNG, and reducing the environmental impacts of natural gas use.

Typically, a research roadmap identifies the current research being conducted within a technology type, research not being conducted (research “gaps), public interest research opportunities within the gaps, potential projects, project priorities and research timeframes (short, medium, long-term) and estimated budgets. The development of technology roadmaps will provide the framework needed with respect to defining future research issues, research project timeframes (e.g., short, medium, long-term), priorities and specific objectives. Development of research roadmaps should provide planning guidance in the first half of 2006, with roadmap implementation occurring during the first quarter of 2007.

### **Budget Re-allocations in the 2005 Program**

Table 2.3 summarizes the 2005 Program Plan Research Subject Area budget allocations and the actual funds obligated in 2005. A total of \$1.85 million was re-directed into the Air Quality Initiative of the Environmental Research Subject Area. All but \$50,000 of the re-direction into the Environmental Research Area occurred as a result of the CPUC and CEC Joint Commission Workshop on Natural Gas Quality Issues held at the CPUC on February 17 and 18, 2005. The \$50,000 is allocated to one of the “transition” projects grouped within the Environmental Research Area. The Workshop Proceedings (Dockets: CPUC R.04-01-025, CEC 04-IEP-01) clearly state in the Next Steps section the need to conduct research to help resolve LNG air quality issues.

The Energy Commission developed natural gas research concepts for the Public Interest Natural Gas program based on the best information available to them in the summer of 2004. However, subsequent justified the need to expand LNG interchangeability research to address short-term needs. The joint workshop began bringing into focus the need for expanding the research efforts, and accelerating the timeline for burner testing and the need to better understand LNG air quality implications.

Table 2.1: 2005 Program Plan Research Issues and Energy Policy

2005 Public Interest Energy Research – Natural Gas Program Plan		
California Natural Gas Policy		Natural Gas Research Issues Tied to Policy
1. Promote Energy Efficiency		<ul style="list-style-type: none"> <li>a) Systematic improvements are needed to improve the efficiency of buildings</li> <li>b) Existing equipment is aging and less efficient resulting in need to find retrofits.</li> <li>c) More innovation is needed to achieve higher building efficiency.</li> <li>d) Better building operational methods will improve building energy efficiency.</li> <li>e) Better thermodynamic efficiencies are needed to improve economics of combustion systems.</li> <li>f) Research is needed to inform policy-makers and provide basis for regulatory changes.</li> </ul>
2. Promote Renewable Energy		<ul style="list-style-type: none"> <li>a) Research is needed to lower the cost of renewable technologies.</li> <li>b) Research is needed to improve the environmental performance of renewable technologies.</li> <li>c) Research is needed to inform policy-makers and provide basis for regulatory changes.</li> </ul>
3. Improve Natural Gas Markets		<ul style="list-style-type: none"> <li>a) Research is needed to improve the means of measuring and predicting the economic impacts of natural gas use in California.</li> <li>b) Research is needed to develop better system tools and models.</li> <li>c) Research is needed to inform policy-makers and provide basis for regulatory changes.</li> </ul>
4. Improve Natural Gas Infrastructure in California	Encourage LNG	<ul style="list-style-type: none"> <li>a) Research is needed to determine the interchangeability of LNG.</li> <li>b) Research is needed to improve security of LNG facilities.</li> </ul>
	Improve Natural Gas Storage	<ul style="list-style-type: none"> <li>a) Develop better reservoir modeling tools.</li> <li>b) Develop better economic tools.</li> <li>c) Research is needed to inform policy-makers and provide basis for regulatory changes.</li> </ul>
5. Reduce Environmental Impacts of Natural Gas Production and Use	Reduce Impacts on Air Quality	<ul style="list-style-type: none"> <li>a) Research is needed to address indoor air quality impacts from natural gas and LNG use.</li> <li>b) Research is needed to address the ambient air quality impacts of LNG or NG use.</li> </ul>
	Address Climate Change Impacts	<ul style="list-style-type: none"> <li>a) Improve monitoring techniques and equipment.</li> <li>b) Improve climate change models.</li> <li>c) Develop mitigation strategies.</li> <li>d) Research is needed to inform policy-makers and provide basis for regulatory changes.</li> </ul>



Table 2.2: 2005 Program Plan, Research Issues and Energy Policy

	California Natural Gas Energy Policy	Promote Efficiency						Promote Renewables		Improve Markets				Infrastructure						Reduce Environmental Impacts					
		Inefficient Buildings	Aging Equipment	Lack of Innovation	Better Operational Methods	Thermodynamic Efficiency	Inform Regulations/Policy	Lower Costs	Environmental Performance	Inform Regulations/Policy	Improve Markets	Better system tools and models	Inform Regulations/Policy	Encourage LNG	Improve Storage	Air Quality	Climate Change								
	Gas Research Issues in 2005 Program Plan																								
	2005 Projects																								
1	Flex Flame Burner Technology For Aluminum Melting																								
2	Field Demonstration of a Prototype Super Boiler																								
3	Characterizing the Energy Efficiency Potential of Gas-fired Commercial Food Service Equipment																								
4	Characterizing the Potential of Gas-Fired Commercial Water Heating Equipment Systems																								
5	Gas Cooling Scoping Study																								
6	Efficient Commercial Gas Fryer for Food Service																								
7	Next Generation Instantaneous Water Heater R&D																								
8	Super Efficient Gas Water Heating Appliance Initiative (SEGWHAI)																								
9	Develop Recommendations to Improve Hot Water Equipment and System Efficiencies in CA Homes																								
10	Super Boiler: Phase I Development <sup>T</sup>																								
11	Development and Demonstration of Ultra-LoNox Burners <sup>T</sup>																								
12	Power Generation and Integrated Steam System <sup>T</sup>																								
13	Develop and Demonstrate a Medium to High Temp. Solar Plant for Food Processing																								
14	Develop and test a low cost, high temp. solar collector system																								
15	Air Qual. Impacts of NG Fuels & Fuel Blends on Combustion Sources																								
16	Improved GHG Inventory Methods for Landfill Gas																								
17	Develop Model to estimate changes of shoreline in No.Cal. Under Different Sea Level Rise Scenarios																								
18	Sustainable Communities Fuel Cell Demo <sup>T</sup>																								
19	Develop new tools and models for natural gas storage																								
	<sup>T</sup> = Transition Project																								

The February 2005 Natural Gas Council's White Paper on Natural Gas Interchangeability and Non-Combustion End Use identified areas where additional data are needed including data for commercial/industrial burners, in use appliances and newer appliances that are designed for high efficiency and fast response. The need for accelerated testing is also demonstrated by the research agenda being developed by the Gas Quality Technical Committee, a stakeholder group representing industry, regulatory agencies and researchers, in funding the planning activities for a commercial/industrial testing program to accelerate the testing of these burners.

Table 2.3: 2005 Program Year Summary

2005 Natural Gas Research Program and Preliminary Funding Summary

Ranked Program Research Area – with ranked Project Initiatives	Plan Allocation Per Program Research Area	Actual 2005 Fund Obligations*
1. Gas Efficiency –	\$5.0 million	
▪ Gas water heating technology		\$2,312,041
▪ Gas space heating technology		\$0
▪ Commercial food service technology		\$572,835
▪ Industrial combustion efficiency		\$600,000
▪ Industrial waste heat recovery		\$0
▪ Gas appliance technology		\$0
▪ Gas space cooling technology		<u>\$129,000</u>
	SUB-TOTAL:	\$3,613,876
2. Renewables	\$2.0 million	
▪ Water heating alternatives		\$0
▪ Process heating alternatives		\$1,300,000
▪ Renewable natural gas fuel replacements		<u>\$0</u>
	SUB-TOTAL:	<b>\$1,300,000</b>
3. Environmental	\$2.25 million	
▪ Air quality impacts and mitigation strategies for combustion of alternative gas supplies (e.g. off-spec and LNG)		\$3,000,000
▪ Climate change adaptation and mitigation-- issues and implications for the natural gas system		<u>\$1,000,000</u>
	SUB-TOTAL:	<b>\$4,000,000</b>
4. Strategic Analyses	\$1.25 million	
▪ Tool and model development to aid in targeting appropriate infrastructure improvements		\$0
▪ Economic research to address State gas energy policy issues		\$868,480
▪ Security related to catastrophic events		<u>\$0</u>
	SUB-TOTAL:	<b>\$868,480</b>
Administration	\$1.5 million	<b>\$1,500,000</b>
Utility Transition Project(s)		<b>\$717,644</b>
Grand Total:	\$12.0 million	<b>\$12.0 million</b>

\*SUBJECT TO ENERGY COMMISSION BUSINESS MEETING APPROVAL

# SECTION 3: 2006 PROGRAM PLAN RESEARCH AREAS AND BUDGETS

## Process Used to Develop the 2006 Plan

During 2005, a number of outreach activities were undertaken to gather input on research topics. Many of these were informal discussions with parties familiar with California natural gas issues, research topics and research needs. In addition, the Energy Commission engaged in two formal outreach activities to gather input. These were:

- The natural gas research community and other stakeholders on the subject of liquefied natural gas and ways that public interest research could assist the state energy policy direction which is to encourage this important, alternative supply source.
- A request for project abstracts, issued July 1, 2005, with abstracts due August 1, 2005. This followed the requirement in CPUC Decision 04-08-010.

Finally, in anticipation of new legislation, the Energy Commission formally engaged the California Air Resources Board (ARB) in a joint planning effort for the 2006 Program Plan.

## Formal Public Outreach

During March of 2005, and with the assistance of the Energy Commission's Natural Gas Analysis Office, the Gas Quality Technical Committee was formed, comprised of representatives from utilities, state regulatory agencies, industry, researchers, air quality regulatory districts and state energy policy staff. The Energy Commission has worked with this group to define research efforts that will provide information needed to formulate policies and regulatory actions affecting LNG use within California. The Committee has provided guidance that changed the allocations of the 2005 Plan budget as well as the proposed budget allocations in the 2006 Plan.

## ARB Co-planning

Effective January 1, 2006, new legislation (SB 76, Section 901 (b) and (c)) states:

*(b) One half of funds allocated pursuant to this article for natural gas public interest energy research and development shall be expended pursuant to a strategic research plan jointly developed by the state Air Resources Board and the Energy Resources Conservation and Development Commission to ensure coordination of the state's energy and environmental research priorities. The plan shall be submitted for review and approval to the commission.*

*(c) Up to one-third of the funds allocated pursuant to this article may be used for transportation related public interest energy research and development provided the research provides natural gas ratepayer benefits and those benefits are identified in the plan.*

Through its PIER electricity program, the Energy Commission has an eight-year history of successful public interest energy research cooperation with the Air Resources Board. To date, over \$6 million of electricity research projects have been funded through the ARB, with an additional \$4 million of research benefiting from ARB advice and direction. This strong, cooperative foundation allowed for relatively seamless co-planning of the 2006 Program Plan with the ARB in a short timeframe. For the 2006 funding proposal, the ARB and CEC will jointly plan the funding of transportation and non-transportation research projects for up to half of the available research funding (\$6.75 million.)

## **Project Abstracts**

The Energy Commission reprised its request for project abstracts for the 2006 Plan, and received 209 abstracts suggesting over \$250 million in funding. The abstract evaluation process proceeded as follows:

### **1. Screening**

Energy Commission research staff used the following screening criterion on all abstracts submitted: Does the Project Abstract describe a public purpose natural gas R&D activity? If so, the abstract proceeded to the second step. If not, the abstract would not be further evaluated. Public Purpose was defined per the CPUC's Decision 04-08-010.

### **2. Sorting**

Abstracts were analyzed for content and assigned to one of the following research subject areas:

- End-use residential, commercial, industrial or agricultural energy efficiency
- Renewable energy
- Environmental Effects
- Transportation
- Strategic Analysis
- Advanced Generation
- Screened (removed from consideration)

Table 3.1 summarizes the abstracts submitted.

Table 3.1 Project Concept Abstracts Received from Utilities and Public

<b><i>Project Concept Abstracts Received from Utilities and Public</i></b>		
Research Subject Area	Number Received	Funding Requested
Efficiency: Residential, Commercial, Industrial and Agricultural	78	\$71.8 million
Environmental Effects	27	\$23.2 million
Transportation	12	\$26.8 million
Renewable Energy	22	\$38.2 million
Strategic Analysis	33	\$19.2 million
Advanced Generation	35	\$60 million
Screened out	2	\$3.7 million
<b>Totals:</b>	<b>209</b>	<b>\$242.9 million</b>

### 3. Abstract Review and Rating

Project Abstracts considered public interest were then ranked within each Program Research Area. The abstracts are ranked as high, medium or low using the following set of criteria:

- Potential Benefits
- Fit within research subject areas
- Connection to State Energy Policy and gas issues identified in California Energy Action Plan
- Potential for success, reasonable probability of providing benefits to the general public
- Whether adequately addressed by competitive or regulated entities
- Consideration of opportunities for collaboration and co-funding opportunities with other entities

For example, an abstract that described a project with clear public purpose (as defined in Decision 04-08-010), addressed natural gas issues identified in State policy, had strong, apparent likelihood for success and indicated credible opportunities for collaboration and shared-funding would be assigned a High (H) rating. Conversely, an abstract that failed to address the criteria in aggregate would be assigned a Low (L) rating.

The Appendix provides a listing of all Abstracts received and their rankings including all abstracts screened out and the reasons for screening them out.

## **New Subject Areas: Transportation and Advanced Generation**

Effective January 1, 2006, new legislation (SB 76, Section 901 (c)) states:

*(c) Up to one-third of the funds allocated pursuant to this article may be used for transportation related public interest energy research and development provided the research provides natural gas ratepayer benefits and those benefits are identified in the plan.*

The “plan” referred to in this Section is the strategic research plan produced jointly with the ARB as described earlier in this section. Up to one third of this year’s budget may be allocated to transportation research in the 2006 funding request.

This funding request is also adding the Advanced Generation research subject area. The Advanced Generation subject area includes research to develop technologies that are more efficient and have lower atmospheric emissions than the base case systems that they replace. This research area will initially focus on Combined Cooling, Heating and Power (CCHP), and natural gas reforming to produce syngas.

## **Grant Program for Concept Feasibility Research**

The Energy Innovations Small Grant (EISG) program, a part of the Public Interest Energy Research (PIER) program, funds early research into concept feasibility on any of the six PIER subject areas in order to support the growth and development of new energy technology concepts. The Program meets the PIER goal of advancing energy science and technology not adequately supported by the regulated and competitive markets.

The Energy Commission proposes to build on its successes in the EISG program, currently funded out of the electricity surcharge account, by augmenting this program with \$1 million out of the \$15 million requested for 2006. During the 2006 Program year, a grant solicitation will invite proposals for concept feasibility research relating to the approved natural gas research areas. The maximum grant award will be \$85,000.

# **Proposed Research Subject Areas and Initiatives for 2006**

## **Research Subject Area 1 - Natural Gas End-Use Efficiency**

This Program Research Area has been given the highest priority ranking because of the aggressive energy efficiency goals established by the CPUC, energy efficiency's position in the "loading order" as defined in the California Energy Action Plan, the importance of efficiency in reducing the growth rate of natural gas consumption in California, and the large number of high potential energy efficiency R&D activities that have been identified in this planning process. With this high priority, the Energy Commission is recommending a 2006 program year budget of \$3.0 million. Funded projects are expected to have one to three year durations.

### **Efficiency Research Problem**

California's core customers, primarily the small industrial, commercial and residential gas customers, consumed approximately 0.66 Tcf of gas in 2003 at an estimated cost to consumers of about \$4 Billion (at \$6/MMBtu). Equipment age, lack of technology innovation, and inefficient buildings and usage practices are principal barriers to efficiency improvements. Technology and market assessments indicate that substantial increases in efficiency and reductions in energy consumption are possible through development of technologies and building practices that are either not currently cost-effective or not effectively commercialized.

California's non-core customers, primarily large industrial customers, consume about 0.75 Tcf of gas per year at a cost to consumers of another \$4.5 billion (again at \$6/MMBtu). This usage constitutes nearly 41% of all gas not used for electric generation in California. If "in-house" electric generation is added, then the industrial sector consumes 33% of all natural gas used in California. Efficient utilization of gas by this sector is often constrained by stringent environmental compliance requirements, lack of new technology and institutional barriers. Substantial increases in efficiency, reductions in energy consumption, and emissions improvements are possible through development and deployment of advanced technologies and operating techniques.

### **Efficiency Objectives and Benefits**

This end use efficiency program includes R&D activities that: (a) reduce the energy input requirements per unit of output (b) reduce energy requirements for service of residential and commercial systems and (c) reduce overall energy consumption by reducing demand for energy consuming goods and services in California residential, commercial and industrial facilities.

The benefits associated with these objectives are improved air quality, decreased use of fossil fuels, reduced expenditures on energy by consumers, and increased statewide and regional economic benefits through less reliance on imported gas supplies.

Specifically, these benefits would include:

- Lower energy consumption, and thus lower energy bills for consumers, through improved combustion, heat transfer, controls, and/or waste heat recovery
- Reduced emissions without an energy efficiency penalty
- Improved reliability of gas supply and delivery systems through reduced demand
- Increased ability to use alternatives to natural gas (for commercial and industrial consumers)

To achieve these benefits, this program will be closely coordinated with ratepayer-funded energy efficiency programs and with the State's building energy efficiency standards and appliance efficiency standards programs.

### **Efficiency Research Initiative Areas**

The Research Initiative areas were selected based on review of the abstracts submitted, the criteria that were established in the CPUC Decision and input from Energy Commission research staff.

#### **Gas Water Heating Technology**

Water heating is one of the highest gas energy uses in the residential sector and is possibly the area with the greatest opportunity for efficiency improvement. This initiative will address the development of reliable and efficient thermal water heating technologies as well as improved water heating distribution designs for both single and multi-family applications. This area is important because of the amount of gas consumed for this end-use and the potential for substantial savings impacts.

#### **Gas Space Heating Technology**

Including both the residential and commercial sectors, gas space heating accounts for the highest gas energy use in the State. This initiative will address high efficiency furnace and boiler development, improved heat recovery systems, and more efficient distribution systems such as locating air ducts inside conditioned space. Substantial improvements may be possible in commercial-scale gas boilers and furnaces, which constitute a large share of commercial and multi-family building heating sources.

#### **Commercial Food Service**

Gas use is extremely high in the food service industry due to inefficient equipment and practices. This initiative will address improved efficiencies for commercial kitchen equipment used for cooking. This area was given high priority because there are many undeveloped opportunities for high-efficiency gas cooking appliances, existing programs that the Energy Commission can collaborate with, and potential for indoor air quality improvements as well as reduced gas consumption.



### **Industrial Combustion Efficiency Improvements**

This initiative covers a wide range of potential activities associated with improving the efficiency of gas combustion. A focus of this work will be research on design, operation and validating the performance of more efficient gas burners and associated control systems, and evaluating the integration of multi-fuel technologies. Combustion efficiency can be severely compromised with increasingly stringent environmental regulations.

### **Industrial Waste Heat Recovery in Industrial Processes**

Large industrial gas-fired thermal sources could permit effective use of waste heat to replace conventional natural gas use. There are many opportunities to add or improve waste heat recovery in industrial processes, although they are constrained by the variety of such processes, the long life of existing equipment, and variations in retrofit and production economics among users. However, there are multiple opportunities for economic recovery of waste heat through the design, operation, and verification of new technologies. Potential projects could include heat exchangers improvements and the development of sensors and controls. Almost 40-60% of process heat is wasted to the atmosphere.

### **Residential and Commercial Gas Appliances**

This initiative will address opportunities for efficiency improvements in residential cooking equipment and residential and commercial clothes dryers. Current gas clothes drying, both in household and larger scales, is a major gas use involving standard mass market products, and its efficiency could be significantly improved with advances in areas such as heat recovery, fabric exposure, and alternative moisture removal technologies. Substantial improvements may be possible in residential and commercial-scale gas appliances and the potential for market introduction is significant given the supply chain and statewide incentive programs.

### **Gas Space Cooling Technology**

Gas cooling currently represents a very small fraction of gas energy use in California and current high costs and technology barriers discourage broader implementation. However, the peak shaving opportunity afforded by gas cooling warrants some continuing research in improved efficiency and reliability of equipment, reduced first costs, and resolution of market barriers to technology adoption. Innovations in gas-powered cooling could provide a new cost-effective strategic approach to electricity peak demand reduction.

### **Systems Optimization Research and Planning**

This initiative addresses such topics as natural gas market analysis, data collection and program planning. Additional important research areas are natural gas equipment and systems integration and optimization. Modeling, software and diagnostic tools are also needed to ensure that natural gas equipment and systems are optimized.

## Research Subject Area 2 - Environmental Implications of Natural Gas Use

This Program Research Areas has been given the second highest priority ranking because of the profound health and welfare impacts of natural gas use and the need for informing State energy policy. With this priority the Energy Commission is recommending a 2006 budget of \$2.75 million.

### Environmental Research Problem

Natural gas is a relatively clean fuel compared to other fossil fuels, but the massive amount of this fuel consumed in California contributes to its air quality problems and is responsible for a large share of the total greenhouse gas (GHG) emissions from in-state sources.

Current standards for natural gas in California are under review in preparation for new LNG supplies that differ in composition (e.g., lower fraction of methane, higher fraction of ethane and other non-methane hydrocarbons) and properties (e.g., higher heating value and Wobbe index<sup>8</sup>). Many in-use NG combustion devices were designed and/or tuned for current fuel formulations. The “interchangeability” or ability of current devices to operate on varying fuel formulations is of concern and a future increase in NO<sub>x</sub> emissions associated with NG variability could impact attainment of the ozone standard. Human exposure to air toxics emitted by NG combustion sources is also of concern. Recent studies employing receptor modeling techniques have implicated NG combustion as an important contributor to ambient PAH and carbonyls, at least in some areas at some times<sup>9</sup>. PM and/or ultrafine particle emissions are areas of concern as their relative contribution may increase along with NO<sub>x</sub>.

The environmental impacts of NG combustion occur on several scales, including: (1) inside residences where appliance emissions lead directly to human exposure [comparative risk studies consistently ranked indoor air pollution among the top four environmental problems], (2) in urban and regional air sheds where NG combustion contributes to overall pollutant levels and visibility degradation and (3) in densely populated areas where air toxics emissions from residential and commercial devices may accumulate and reach high concentrations in outdoor air when atmospheric mixing is limited. Foremost among the impacts of NG use is human exposure to emitted air pollutants. NG combustion produces carbon monoxide (CO), volatile organic compounds (VOC), nitrogen oxides including principally NO and NO<sub>2</sub>, and condensable organic compounds that form fine particles (PM<sub>2.5</sub>). CO, NO<sub>2</sub> and PM<sub>2.5</sub> are regulated as “criteria air pollutants” with associated health-based state and national ambient air quality

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<sup>8</sup> Wobbe index is fuel energy content normalized to the square root of specific gravity (gas density related to air), and thus represents energy delivered through an orifice per unit time.

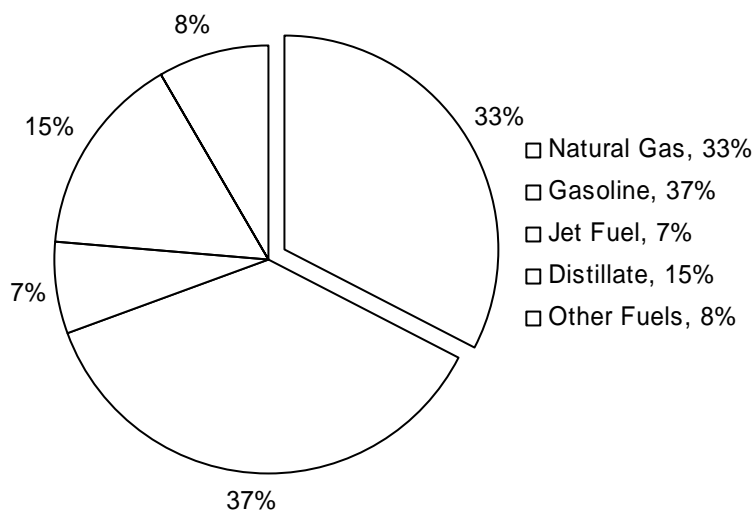
<sup>9</sup> Lee, J. H.; Gigliotti, C. L.; Offenberger, J. H.; Eisenreich, S. J.; Turpin, B. J. Sources of polycyclic aromatic hydrocarbons to the Hudson river airshed. *Atmos Environ* **2004**, 38, 5971-5981.

standards. Emitted organic compounds include state-regulated toxic air contaminants (TACs)<sup>10</sup>, notably formaldehyde, acrolein and polycyclic aromatic hydrocarbons (PAH). Additional NG-associated pollutants with significant health concern are “ultrafine” particles. NG emissions contribute to visibility degradation via directly-emitted fine particles and nitrogen oxides that react form nitric acid (HNO<sub>3</sub>) and nitrate aerosol.

Governor Schwarzenegger signed an Executive Order on June 1, 2005 establishing greenhouse (GHG) emission targets for California. According to this order, year 2020 GHG emissions should be at lower than historical year 2000 GHG emissions and emissions in 2010 should go down to 1990 levels. The ramifications of this order are far reaching potentially affecting every sector of the state economy.

Natural gas consumption in California contributes about 33 percent of the total carbon dioxide emissions released during the combustions of fossil fuels in the state (see the figure below). This amount is similar to the contribution of motor gasoline used mostly as a fuel in automobiles, which anecdotally is believed to be the dominant source of carbon dioxide emissions in the state. Since natural gas consumption represents a major source of carbon dioxide emissions in the state, a research program funded by natural gas rate payers should address the environmental and economic implications of climate change.

Fig. 3.1: Carbon Dioxide Emissions by Fuel Type: 2002



Greenhouse gas reduction initiatives may translate in increased demand for natural gas due to its relatively low carbon dioxide emissions. Increased demand may result in higher prices and accelerate the introduction of liquefied natural gas (LNG) into the market.

### Environmental Objectives and Benefits

<sup>10</sup> The 1990 Clean Air Act Amendments direct the U.S. EPA to set regulations to reduce exposures to 189 hazardous air pollutants (HAPs) with authority to amend the list based on a scientific review process. California regulates toxic air contaminants (TACs) that include the Federal HAPs plus additional compounds identified by the state.

This environmental Research Area includes R&D activities that: (a) evaluate air quality and climate change impacts of use of natural gas and non-traditional natural gas in stationary applications, (b) identify measures to reduce negative impacts from use of those fuels, and (c) investigate strategies the state should take to adapt to a changing climate.

This portfolio of projects will address potential future air quality impacts of the use of natural gas and non-traditional blends and provide guidance on what actions are needed to reduce or eliminate impacts. It will also greatly improve the understanding of indoor air quality impacts of natural gas combustion in residences and aid in increasing awareness of potential health risks and identifying appropriate measures to reduce those risks.

As California embarks on an ambitious path towards alternative fuels for stationary and transportation applications, there is a need to understand the impacts of the shift on the natural gas system.

### **Environmental Research Initiative Areas**

The Research Initiative areas were selected based on review of the abstracts submitted, the criteria that were established in the CPUC Decision and input from Energy Commission research staff.

#### **Air quality impacts of the combustion of different qualities of gas supplies**

This initiative identifies the potential effect, on power plant and other combustion sources, emissions from use of non-traditional supplies of natural gas. The primary focus will be on characterizing the impacts (regional and indoor) and identifying appropriate measures to mitigate impacts from use of those non-traditional supplies of natural gas, e.g. off-spec and LNG. This area was given the highest priority ranking because air quality impacts of this increased use of non-traditional supplies are not well understood and are of considerable concern to California.

It is expected that the research related to the interchangeability of natural gas formulations is a multi-year funded program. The program is focused on variable fuels and includes: (1) measurement of safety, performance and direct exhaust emissions for current and emerging combustion technology; (2) chamber-based experiments to quantify exposure relevant pollutant emission rates for properly-functioning, un-vented appliances; (3) in-the-field quantification of emissions from as-installed appliances with follow-up measurements; (4) application and development of modeling tools to investigate the effect of fuel variability on safety, performance and emissions; (5) development of protocols and testing of fuel variability effects on commercial/industrial burners; (6) study of incremental health risks resulting from indoor air pollutant exposures; (7) evaluation of ambient air quality impacts; and (8) synthesis of information in risk assessment and mitigation planning.

## **Climate Change Adaptation and Mitigation-- Issues and Implications for the Natural Gas System**

Natural gas consumption is a major source of GHG emissions and efforts to reduce GHG emissions at the state levels may affect the demand and supply of natural gas. Research funded under this program will address the environmental implications of climate change including physical impacts, economic impacts, options to reduce emissions and adaptation options. This initiative complements on-going work on climate change funded by the Public Interest Energy Research (PIER) Program.

### **Development of tools needed for long-term analysis of the implication of climate change policies on the natural gas system.**

This initiative involves the design and/or enhancement of techniques to realistically simulate the natural gas system in California. This work includes for example, an assessment of the perfect foresight assumption in some of the existing natural gas system models, which render them unsuitable for realistic long-term analyses.

### **Potential to Reduce GHG Emissions from the Natural Gas System.**

This initiative will involve first a scoping study to better understand the nature and extent of emissions and field studies to improve the methods used to estimate GHG emissions from the natural gas system. It will include ambient air monitoring and modeling to establish the source of emissions. Thus study may include an engineering study of the options available to reduce emissions from this sector.

### **Improved Methods to Estimate Methane emissions from Landfills.**

Landfills are a major source of methane emissions in California. The methods used to estimate emissions for the current inventories are known to be problematic. Comparison of estimated emissions and measured emissions sometimes suggest that existing methods severely under or over estimate emissions depending on the specific landfill under study. Control of methane emissions from landfills however, are expected to be one of the most cost effective measures available to reduce emissions.

### **Development of Long-term energy efficiency supply curves for the Natural Gas System.**

Utilities in California are developing energy efficiency supply curves that look at opportunities to reduce energy demand in the next 10 years. The Natural Gas Research Program plans to use this study to develop long-term energy efficiency supply curves for the next 30 to 40 years. This initiative will be important for generating regional estimates for important demand areas in California.

## **Research Subject Area 3 – Transportation**

Effective January 1, 2006, new legislation (SB 76, Section 901 (c)) states:

*(c) Up to one-third of the funds allocated pursuant to this article may be used for transportation related public interest energy research and*

*development provided the research provides natural gas ratepayer benefits and those benefits are identified in the plan.*

The “plan” referred to in this Section is the strategic research plan produced jointly with the ARB as described earlier in this section. Up to one third of the 2006 Plan budget may be allocated to transportation research. Discussions with the ARB have shown potential, near-term research that will provide benefits to gas ratepayers and the transportation sector. Therefore, the 2006 Plan is requesting \$3 million to be allocated to near-term transportation research.

The Energy Commission will invite the ARB and other stakeholders to work in a strategic research planning effort during 2005 and 2006 that will identify the policy framework and long-range research goals for both transportation and non-transportation, public interest natural gas energy research, and comply with Article 901 (b) of SB 76. Results of this strategic planning could result in modifying the 2006 Program budget to fund additional transportation research. In this event, an amended budget summary showing new research area budgets will be provided to the CPUC for approval during the first quarter of 2006.

## **Research Subject Area 4 - Renewable Natural Gas Alternatives**

This Program Research Areas has been given the third highest priority ranking because of the importance of renewables with respect to reducing California’s dependency on natural gas imports. With this priority, the Energy Commission is recommending a 2006 program year budget of \$1.5 million. As more R&D is conducted, funding and priority adjustments will be considered for future years. Funded projects are expected to have one to three year durations.

### **Renewables Research Problem**

California’s wealth of renewable resources are spread geographically throughout the state. In a number of situations, renewable resources could be used in lieu of natural gas. For example, solar energy can be harnessed to provide hot water for residential, commercial and industrial purposes. Similarly, “biogas” resources generated from landfills, wastewater treatment facilities, dairy operations and food processing plants can be cleaned and substituted for natural gas. Moreover, substituting “biogas” resources for natural gas also helps address environmental issues posed by disposal of the biomass residues that act as sources of the biogas. However, increases in conversion efficiency, lower costs and improved environmental performance are needed to make these renewable natural gas alternatives viable in California’s energy markets.

## **Renewables Objectives and Benefits**

The renewables program area includes R&D activities that reduce overall gas consumption by developing alternative energy sources for California residential, commercial and/or industrial sectors. The benefits associated with this Research Area are decreases in the consumption of gas and the resulting improved air quality (including potential reduction in the environmental impacts associated with current disposal practices for California's biomass residues), potential reduced expenditures on energy by consumers, and increased statewide and regional economic benefits through less reliance on imported gas supplies. To achieve these benefits, this program will be closely coordinated with the Energy Commission's and other entities renewable energy incentive and education programs.

## **Renewables Research Initiative Areas**

The Research Initiative areas were selected based on review of the abstracts submitted, the criteria that were established in the CPUC Decision and input from Energy Commission research staff.

### **Water Heating Alternatives**

This initiative addresses cost-effective alternatives to gas fueled water heating in residential and commercial applications. The primary focus will be on low cost, higher efficiency solar water heating for residential and commercial use; combined renewable electric (e.g., photovoltaics) and solar water heating technologies and thermophotovoltaic water heating technologies. This area was given the highest ranking because of the potential for substantial, and quick-to-market, technology improvements in an end-use with high gas usage.

### **Process Heating Alternatives for Industry**

This initiative addresses finding cost-effective alternatives to gas fueled water heating, steam generation and drying in industrial applications. The primary focus will be on renewable fuels for commercial and industrial process heating and combined concentrating solar power electric/thermal technologies to meet combined heat and power needs. This area was given its priority because of the potential for introducing alternative gas resources within the industrial market sector.

### **Renewable Natural Gas Replacement Alternatives**

This initiative addresses finding cost-effective, renewable alternatives to conventional natural gas resources. The primary focus will be on improved biogas, including landfill gas and digester gas, technologies for meeting on-site agricultural natural gas use, enhanced methods for cleaning biogas to develop cost-competitive natural gas substitutes, and improved biomass to biogas and thermal gasification conversion methods to increase renewable natural gas alternatives. This area deserves its priority because of the potential for expanding the use of alternative gas supplies within California's gas distribution and utilization infrastructures.

## **Research Subject Area 5 – Strategic Analyses**

In order to ensure the State's policy objective of having a secure, reliable and reasonably priced gas resource, and more research is required to understand important gas related infrastructure issues and options facing California. Thus, development of research tools and models, economic research, and strategic analyses of gas issues is ranked as the fourth priority for R&D in 2006. For California, these issues address questions and options associated with supply, transportation, storage, consumption and security. While a significant amount of public interest energy research has been devoted to electricity use, transmission/distribution and supply in California, little effort has been focused on economic tools and analyses of gas issues.

The Energy Commission is recommending a 2006 program year budget of \$1.5 million. This funding level is recommended to augment the three priority issues outlined in the CPUC Decision. The funding level is lower than the other three Program Areas because of its lower priority ranking and the relatively low cost of research expected to be conducted in this Area. Funded projects are expected to have one to two year durations.

In the latter half 2005, the Strategic Analysis Research Area will launch a grant program addressing natural gas storage planning, development and operations especially as they intersect with LNG. In 2006 Strategic Analysis will focus on natural gas infrastructure research and the development of a Strategic Analysis research advisory committee. The advisory committee will be made up of stakeholders from industry, academia, government and the public. It will be a part of a process that should result in a Strategic Analysis Research Area roadmap in time to inform the 2007 program plan.

### **Strategic Analyses Research Problem**

California's gas markets are a complex web of regulated and non-regulated activities associated with the exploration and development of in-state natural gas resources, the importation of natural gas from outside of the state, the distribution of the natural gas, storage of natural gas, and the use of the natural gas by a wide range of both core and non-core customers. The improvement of the state's natural gas infrastructure requires an understanding of the technical issues and economic impacts of various options. (The environmental impacts associated with improvements in the infrastructure are addressed in the Environmental Research Area.) This understanding requires the development of analysis tools and models as well as doing the analyses to inform policy makers on opportunities for targeted infrastructure improvements. One of the infrastructure issues of particular importance is reliability of the natural gas system in the event of a catastrophic disaster, both man-made (e.g. terrorism) and natural (e.g. earthquakes). Thus, this area may also include research associated with improving continuation of supply and distribution beyond current norms.



## **Strategic Analyses Objectives and Benefits**

Strategic R&D topics will focus on optimizing technology investments with clear public benefits as defined in the Decision. Strategic research results are also expected to inform policy decisions. To understand and select the best infrastructure and resources for California, tools and models will be developed and analyses conducted on a wide range of subjects. This work will provide information for policy decisions and optimal allocation of future technology development funds.

The proposed benefits of this work will occur in part through more timely, better informed, and effective policy decisions by State officials as well as natural gas service providers. This area's research will permit improved pipeline security from both earthquake and intentional damage, more economical and stable natural gas prices through improved cost structures and natural gas storage strategies, and improved understanding of market structure and regulatory actions' effect on prices and availability. Other strategic R&D benefits may be relatively specific, such as optimization of slack pipeline capacity to improve infrastructure efficiency and storage volume to mitigate peak demands, supplier price spikes, or supply interruptions.

## **Strategic Analyses Research Initiative Areas**

In the Strategic Analyses Research Area, projects will be developed to meet the highest-priority needs for State policy development and decision-making. These strategic studies may include collaborative research with private natural gas industry enterprises as well as federal and other public authorities. The results of such studies will inform policymakers and energy providers as well as technology innovators. The potential environmental Research Initiative areas are listed in the order of priority according to the criteria established for this purpose in the CPUC Decision.

### **Tool and Model Development to Aid in Targeting Appropriate Infrastructure Improvements**

This initiative will develop technical and economic models and tools. The primary focus will be on such products such as dynamic, real-time, tools to optimize the real time slack capacity needed in pipelines, beyond rule of thumb; tools for analyzing public benefits and costs of increased gas storage; and models and tools to improve the economic efficiency of buying/selling/storing gas and the analysis of different regulatory frameworks. This area is given the highest priority because of the need for developing such products.

### **Economic Research to Address State Gas Energy Policy Issues**

This initiative involves conducting actual economic analyses of California's gas markets. The primary focus will be on valuing increased gas storage; effects of continued growth of gas-fired electricity generation capacity in California on energy price stability and environmental quality; market response and economic effects of alternative cost and incentive structures for gas, and quantifying California ratepayer cost impacts from introduction of new gas supplies. This area is given the second highest priority because of the need for the analyses as identified by State gas energy experts.

### **Security Related to Catastrophic Events**

This initiative will address ways to mitigate risks to the State from catastrophic damage to the state's gas infrastructure. Activities may include: developing techniques and estimates of impacts of catastrophic natural and intentional events, seismic hazards and risk/cost analyses for California gas infrastructure, developing security strategies and implications for gas infrastructure, and gas-electricity interdependence analyses that include and effects of alternative policies on energy supply reliability in disruptive events.

### **Research Subject Area 6 – Advanced Generation**

This Program Research Area addresses issues of natural gas efficiency, with the highest priority ranking, and the environmental implications of natural gas use, with the second highest priority ranking. The importance of efficiency in reducing the growth rate of natural gas consumption in California is reflected in energy efficiency's and distributed generation's positions in the "loading order" as defined in the California Energy Action Plan. Environmental policy, including issues of air quality and global climate change, has profound health and welfare implications. Given these priorities, the Energy Commission is recommending a 2006 program year budget of \$750,000 for Advanced Generation research. Funded projects are expected to have durations of one to three years.

#### **Advanced Generation Research Problem**

With natural gas usage for on-site generation included, the industrial sector consumes 33% of the total natural gas used in California. On-site generation in the commercial and industrial sectors is constrained by environmental compliance requirements, lack of suitable technologies and institutional barriers. Substantial increases in efficiency, reductions in energy consumption, and emissions improvements are possible through development and deployment of advanced technologies, operating techniques and combined cooling, heating and electricity generation.

The Energy Action Plan promotes customer and utility-owned distributed generation (DG): clean, small generation resources located at load centers. Benefits include energy reliability and availability, energy security, reduced congestion of transmission and distribution systems, grid support, and demand response opportunities. However, most non-renewable DG technologies cannot match the efficiency and emissions performance of central station power plants. But there are exceptions: 1) combined cooling, heating and power (CCHP) systems, which can have system efficiencies exceeding 80%, and 2) fuel cells, some of which can have fuel-to-electricity efficiencies of 60-65% with no pollutant emissions. A third strategy is to use the waste heat from a DG system to reform some of the natural gas to a mixture of hydrogen and carbon dioxide. Natural gas plus the reformat has a higher fuel value and can burn more cleanly than natural gas alone. Technology development and deployment will lead to reduced NG consumption and improved air quality.

There are institutional and technical barriers to the implementation of CCHP systems. Air emissions regulations need to give proper credit for complete system performance. Air quality regulations compare CCHP system air emissions to the newest natural gas fired central station power plants rather than taking a more holistic view of CCHP system criteria emissions and efficiency in comparison to the existing fleet of central station plants, including out of state coal plants, the distributed generator, on site boilers and heaters that are displaced, and the associated carbon dioxide emissions.

Most CCHP systems are “stick built,” designed by engineers using performance specifications determined by component manufacturers. Standardized testing protocols are needed so that engineers can accurately compare specifications, and integrated systems that optimize the performance of the generation and heating and/or cooling subsystems are needed.

For most stationary fuel cells, the requisite hydrogen fuel is supplied by reforming natural gas. RD&D is needed to improve the performance of reformers. Furthermore, advanced reformer technologies have the potential to improve the efficiency and reduce the emissions of other DG prime movers, such as reciprocating internal combustion natural gas engines, by converting waste heat into hydrogen and carbon monoxide fuels. Internal combustion engines are widely used for DG applications such as NG pipeline pressurization and grid support.

### **Advanced Generation Objectives and Benefits**

The Advanced Generation subject area includes research to develop technologies that are more efficient and have lower atmospheric emissions than the base case systems that they replace.

Benefits would include:

- Lower grid electricity and fuel consumption, and thus lower energy bills for consumers, through improved combustion, heat transfer, controls, and/or waste heat utilization
- Reduced emissions without an energy efficiency penalty
- Improved reliability of gas supply and delivery systems through reduced demand

### **Advanced Generation Research Initiative Areas**

The Research Initiative areas were selected based on review of the abstracts submitted, the criteria that were established in the CPUC Decision and input from Energy Commission research staff.

### **Combined Cooling, Heating and Power (CCHP)**

This initiative covers a multitude of industrial end use applications that use process heat, allowing a company to generate a portion of its own electricity with a gas-fired engine, and utilize the waste heat from the engine to provide the process heat (for a high temperature furnace, boiler, absorption chiller, etc.). A properly designed system has economic, energy efficiency (fuel to electricity and process heating, shaft power, and/or cooling) and atmospheric emissions over the conventional utility supplied electricity and site supplied process heating.

Specific research initiative is the development of innovative approaches and packages for the combined production of hot water, hot air, steam compressed air, cooling, mechanical drive power, and electric power. Goals are to have better efficiency, lower cost and lower emissions than the separate purchase of electricity and the on-site production thermal energy to process

### **Natural Gas Reforming to Produce Syngas**

Through the process of chemical recuperation, waste exhaust heat from a turbine or engine can be used to convert some of the natural gas supplied to the turbine or engine and water to a synthetic gas consisting of unreacted natural gas, carbon monoxide, hydrogen, and non-combustible gases. This process is already commonly used in a different form to supply hydrogen to fuel cells. There are several intriguing aspects to chemical recuperation. First, waste heat is converted to a fuel that can be used to produce more electricity. Second, hydrogen has combustion characteristics that stabilize the combustion of the natural gas plus synthetic gas mixture. The mixture burns more cleanly than natural gas alone. Third, the synthetic gas can be diverted and separated into its constituents, including hydrogen, which can be used for other applications.

Goals are to design, fabricate and operate a complete engine or turbine system with chemical recuperation and to demonstrate the energy efficiency and environmental benefits.

## **2006 Program Plan Policy Framework**

Table 3.2 lists the research issues derived from the Problem Statements for each Subject Area, mapped to California natural gas policies. The research issues identified in this year's funding request differ slightly from those in the 2005 Program Plan (Table 2.1) in that additional research into markets is anticipated. It is expected that transportation policies relating to natural gas, and associated research issues, will be jointly identified with the ARB during the first quarter of 2006, in conjunction with selecting near-term, transportation research project opportunities. A map of research issues and natural gas-transportation policies will also be produced.

Table 3.2: Research Initiatives and California Natural Gas Policies

2006 Public Interest Energy Research – Natural Gas Program Plan		
California Natural Gas Policy		Natural Gas Research Issues Tied to Policy
1. Promote Energy Efficiency		<ul style="list-style-type: none"> <li>a) Systematic improvements are needed to improve the efficiency of buildings</li> <li>b) Existing equipment is aging and less efficient resulting in need to find retrofits.</li> <li>c) More innovation is needed to achieve higher building efficiency.</li> <li>d) Better building operational methods will improve building energy efficiency.</li> <li>e) Better thermodynamic efficiencies are needed to improve economics of combustion systems.</li> <li>f) Research is needed to inform policy-makers and provide basis for regulatory changes.</li> </ul>
2. Promote Renewable Energy		<ul style="list-style-type: none"> <li>a) Research is needed to lower the cost of renewable technologies.</li> <li>b) Research is needed to improve the environmental performance of renewable technologies.</li> <li>c) Research is needed to inform policy-makers and provide basis for regulatory changes.</li> </ul>
3. Improve Natural Gas Markets		<ul style="list-style-type: none"> <li>a) Research is needed to improve the means of measuring and predicting the economic impacts of natural gas use in California.</li> <li>b) Research is needed to develop better system tools and models.</li> <li>c) Research is needed to inform policy-makers and provide basis for regulatory changes.</li> </ul>
4. Improve Natural Gas Infrastructure in California	Encourage LNG	<ul style="list-style-type: none"> <li>a) Research is needed to determine the interchangeability of LNG.</li> <li>b) Research is needed to determine the impact on gas prices &amp; system reliability of various fuel specifications, including LNG</li> <li>c) Research is needed to improve security of LNG facilities.</li> <li>d) Research is needed to inform policy-makers and provide basis for regulatory changes.</li> </ul>
	Improve Natural Gas Storage	<ul style="list-style-type: none"> <li>a) Develop better reservoir modeling tools.</li> <li>b) Develop better economic tools.</li> <li>c) Research is needed to inform policy-makers and provide basis for regulatory changes.</li> </ul>
5. Reduce Environmental Impacts of Natural Gas Production and Use	Reduce Impacts on Air Quality	<ul style="list-style-type: none"> <li>a) Research is needed to address indoor air quality impacts from natural gas and LNG use.</li> <li>b) Research is needed to address the ambient air quality impacts of LNG or NG use.</li> <li>c) Research is needed to inform policy-makers and provide basis for regulatory changes.</li> </ul>
	Address Climate Change Impacts	<ul style="list-style-type: none"> <li>a) Improve monitoring techniques and equipment.</li> <li>b) Improve climate change models.</li> <li>c) Develop mitigation strategies.</li> <li>d) Research is needed to inform policy-makers and provide basis for regulatory changes.</li> </ul>

Fig. 3.2: 2006 PIER Natural Gas Funding Summary

Ranked Research Subject Areas – with Research Initiatives	Description of Subject Area	Budget Allocation Per Research Subject Area
1. Gas Efficiency <ul style="list-style-type: none"> <li>▪ Gas water heating technology</li> <li>▪ Gas space heating technology</li> <li>▪ Commercial food service technology</li> <li>▪ Industrial combustion efficiency</li> <li>▪ Industrial waste heat recovery</li> <li>▪ Gas appliance technology</li> <li>▪ Gas space cooling technology</li> <li>▪ Systems optimization research and planning</li> </ul>	This area focuses on improving the efficiency of gas consuming equipment and systems in the residential, commercial and industrial sectors.	\$3.0 million
2. Environmental <ul style="list-style-type: none"> <li>▪ Air quality impacts and mitigation strategies for combustion of alternative gas supplies (e.g. off-spec and LNG)</li> <li>▪ Climate change adaptation and mitigation--issues and implications for the natural gas system</li> </ul>	This research will improve analytical capability for assessing potential criteria air pollutant (indoor and regional) and greenhouse gas impacts and mitigation strategies for traditional and non-traditional NG blends.	\$2.75 million
3. Transportation	Research initiatives to be developed 1 <sup>st</sup> quarter, '06.	\$3.0 million
4. Renewables <ul style="list-style-type: none"> <li>▪ Water heating alternatives</li> <li>▪ Process heating alternatives</li> <li>▪ Renewable natural gas fuel replacements</li> </ul>	This area focuses on developing and commercializing alternative fuel sources, particularly solar energy and biofuels.	\$1.5 million
5. Strategic Analyses <ul style="list-style-type: none"> <li>▪ Tool and model development to aid in targeting appropriate infrastructure improvements</li> <li>▪ Economic research to address State gas energy policy issues</li> <li>▪ Security related to catastrophic events</li> </ul>	This research addresses topics such as value of increased gas storage; impact on gas prices and reliability of various fuel specifications, including off-spec and LNG; market analysis, identifying real time slack capacity needed in pipelines and mitigating impact of catastrophic events (e.g., earthquakes and terrorism).	\$1.5 million
6. Advanced Generation <ul style="list-style-type: none"> <li>▪ Combined cooling, heating and power (CCHP)</li> <li>▪ Natural gas reformers for fuel cells, turbines, and reciprocating engines</li> </ul>	This research will improve the efficiency and reduce the emissions from natural gas used in commercial and industrial electricity generation, process heating and cooling.	\$0.75 million
Small Grant Program	Concept feasibility research across all '06 subject areas.	\$1.0 million
Administration	Includes planning, project selection, contracting, project management and reporting.	\$1.5 million
Total		\$15.0 million

## Prioritized Research Areas and Budget for 2006

Figure 3.2 (previous page) summarizes the research areas and budget proposed for the 2006 funding year of the PIER Natural Gas program.

As happened in the 2005 program year, it is expected that some re-allocation of the research subject area budgets will likely occur during the 2006 program year (e.g., re-allocations into the Transportation research subject area.) The Energy Commission will develop and implement any research subject area budget change in coordination with the CPUC.

## Rejected Research Subject Areas

The Energy Commission received a number of suggestions for public purpose gas R&D activities. One area was rejected as either not being public purpose or inconsistent with the CPUC Order, or State law:

### Research addressing hydrogen as a transportation fuel

SB 76 states that the research funds allocated to transportation shall not be used for the California Hydrogen Blueprint Plan:

*(b) One half of funds allocated pursuant to this article for natural gas public interest energy research and development shall be expended pursuant to a strategic research plan jointly developed by the state Air Resources Board and the Energy Resources Conservation and Development Commission to ensure coordination of the state's energy and environmental research priorities. The plan shall be submitted for review and approval to the commission.*

*(c) Up to one-third of the funds allocated pursuant to this article may be used for transportation related public interest energy research and development provided the research provides natural gas ratepayer benefits and those benefits are identified in the plan.*

***(d) Funds allocated in subdivisions (b) and (c) shall not be used for the California Hydrogen Blueprint Plan.***

## SECTION 4: PROGRAM IMPLEMENTATION AND ADMINISTRATION

### Administration

#### 2005 Program Year Administration Costs

Administration expenses in the 2005 Program year were allocated to staffing and program technical assistance. The CPUC authorized funds in the amount of \$200,000 to the California Energy Commission in 2004 for PIER Natural Gas Program personnel expenses. The \$200,000 has been allocated to cover staff hours expended during the first half of 2005 for program implementation. The Energy Commission subsequently initiated and received approval for a Budget Change Proposal (BCP) justifying five civil service staff positions for the new program in FY 05/06. All five positions were filled during the first six months of the 2005 program year. When the BCP was approved by the Department of Finance, \$535,000 of natural gas public purpose surcharge funds were appropriated in the FY 05/06 budget for personnel expenses for the 2005 Program year. Half of this BCP amount will be expended during the latter half of 2005. The Energy Commission also encumbered \$1.032 million into an existing contract with the University of California for program technical assistance. Administrative expenses for 2004 (program implementation) and the 2005 Program year are summarized in Table 4.1.

Table 4.1: Administrative Expenses for the 2005 Program Year			
Expense Category	Funds Obligated 2005 Program Year		Sub-Totals
Personnel	\$200,000 CPUC Authorized, 2004	\$267,500 Appropriated in Budget Act	\$467,500
Technical Assistance	\$100,000 Encumbered in 2004	\$932,500 Encumbered in 2005	\$1,032,500
Grand Total:			\$1.5 million Obligated

#### Additional Personnel for the Research Program

The Energy Commission has submitted a Budget Change Proposal (BCP) for approximately \$500,000 to add 5 additional positions to the program, starting FY 06/07. The exact amount of the BCP will be determined if and when it receives Department of Finance approval in the third quarter of 2005.



## **2006 Program Year Proposed Administration Costs**

The 2006 Program Plan proposes an administration budget of \$1.5 million. These funds will be used to cover personnel expenses and provide technical assistance for the program. Personnel assigned to the Program will typically manage daily program activities and projects, conduct program planning, develop projects, and evaluate the program. Technical Assistance and personnel expenses for the 2006 Program year are expected to be \$984,000 and \$516,000 respectively.

## **Research Contracting**

When AB 1732 became law, the PIER – Natural Gas program was enabled with the same contracting and administrative abilities currently enjoyed by the PIER-Electricity program. These abilities are summarized as follows:

1. Sole Source Provisions.
  - Oversight is maintained since all sole source agreements go to joint legislative budget committee for 30-day review.
  - Facilitates continuity of phased research efforts and reduces project risk to state.
  - Facilitates multiparty research efforts.
2. Multiparty Agreements
  - Facilitates co-funding of research and leverages state funds
  - Facilitates collaborative research
  - Facilitates aggregation and expert coordination of related groups of projects
3. Grants
  - Enable streamlined awards for exploratory research
  - Allow for faster and less-complex competitive solicitations compared to contract awards.
4. Intellectual Property Provisions
  - Clear Rights to Intellectual Property: PIER intellectual property provisions are designed to facilitate organizations participating in research that might otherwise chose not to under standard State contracting terms.
  - The PIER provisions applicable to the natural gas research program will enable equitable sharing of intellectual property rights so that research benefits can more easily accrue to California citizens.
5. Specific Awards for Program Technical Support
  - Enables choice of specific expertise for specific technical needs
  - Allows awarding groups of technical support providers under a single contract
6. Insurance Coverage
  - Facilitates multiparty agreements by allowing CEC to purchase specialized, temporary policies

## **Long-term Planning for Natural Gas R&D**

The Public Interest Energy Research (PIER) Program is required to submit a Five Year Plan to the state legislature by March 15, 2006. In addition, the PIER electricity program is required by law to develop a staffing and resource plan to support the five-year plan. To address these requirements, PIER management started a strategic planning process in July 2005 that will culminate in the development of the 5-year plan and the staffing plan by March 15<sup>th</sup>, 2006. The Five Year Plan will address public interest electricity and natural gas research strategies, as well as address transportation research for natural gas and electricity. The Five Year Plan will consist of the following parts:

1. The Strategic Electricity and Transportation/Electricity Public Interest Energy Research Plan.
2. The Strategic Natural Gas and Transportation/Natural Gas Public Interest Energy Research Plan.
3. The Research and Development Staffing and Resource Plan

This process was started on July 7, 2005 with an all-day, facilitated meeting that involved research stakeholders from the Energy Commission, gas and electric utilities, the Gas Research Institute, the California Institute for Energy and the Environment, the University of California, national laboratories, private firms and other state agencies. The Five Year Plan will be the primary venue used to accomplish co-planning of the natural gas program with the California Air Resources Board. Workshops will be held in the fall of 2005 and spring of 2006 and will provide opportunities for public input on the plan and the planning process.

## **Public Outreach**

During the 2006 Program year, the primary public outreach effort will occur through the Five Year Plan development process. Other, more focused outreach will occur as research roadmaps are developed.

## **Research Program Integration**

The PIER Natural Gas program resides within the Energy Research and Development (ERD) Division of the Energy Commission. In addition to administering the PIER Natural Gas program, ERD has also implemented the Electricity Public Interest Energy Research program for seven years. The PIER Program annually awards up to \$62 million to conduct the most promising public interest energy research by partnering with RD&D organizations including individuals, businesses, utilities, and public or private research institutions.

PIER brings new energy services and products to the marketplace and creates statewide environmental and economic benefits. PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grant Program
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally-Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies

The research expertise nascent within the PIER electricity program subject areas is being used to effectively implement the PIER natural gas program.

# APPENDIX A: GAS R&D PROJECT ABSTRACTS SUMMARY

This appendix contains two tables. The first shows abstracts that were allocated to the six Program Research Subject Areas and ranked high, medium or low. The second table lists the abstracts screened out for 2005 and the reasons for screening.

**Table A-1: Gas R&D Abstract List by Category**

<b>Category</b>	<b>ID#</b>	<b>Rank</b>	<b>Project Title</b>
1 - Efficiency	32	H	A New Concept in High Efficiency Natural Gas Fired Space Heating
1 - Efficiency	165	H	Over-fired Broiler Improvements
1 - Efficiency	56	H	Benefits from a Statewide Natural Gas Energy Efficiency Program
1 - Efficiency	84	H	National Gas Efficiency Program Conference Co-Sponsorship
1 - Efficiency	190	H	Automated Building Diagnostics/Continuous Commissioning Software
1 - Efficiency	202	H	Gas Research and Development Project Concept Abstract - Curbing Califo
1 - Efficiency	39	H	Optimizing or eliminating reheat in high tech buildings
1 - Efficiency	73	H	Natural draft Low NOx Burners for Water Heaters and Furnaces
1 - Efficiency	200	H	Demonstration of Tri-Generation of Electricity, Heat and Hydrogen
1 - Efficiency	47	H	Near-zero Excess air Ultra-clean Industrial & Commercial Burners
1 - Efficiency	60	H	Low-Cost Sensors for Efficiency Optimization of Large Gas Burners
1 - Efficiency	99	H	Dual Natural Gas – Electric Hybrid Heaters
1 - Efficiency	100	H	High Efficiency Gas-Fired Drum Dryer for Food Processing
1 - Efficiency	106	H	High Efficiency Industrial Ovens
1 - Efficiency	113	H	On-Line Inspection of Pressure Vessels and Pipes
1 - Efficiency	133	H	Deployment of the Reverse Annulus Single Ended Radiant Tube (RASERT)
1 - Efficiency	207	H	Absorption Heat pump Powered Dryer
1 - Efficiency	108	H	Field Demonstration of Low NOx/CO Burners for Crude Oil Heaters
1 - Efficiency	22	M	Gas fired Heat Pump for Commercial and Light Industrial Applications
1 - Efficiency	29	M	Gas Engine-Driven Chiller in Innovative Heating Application
1 - Efficiency	69	M	Unitary LiBr Absorption Heating and Cooling System
1 - Efficiency	89	M	Low-Cost Condensing Commercial Water Heater
1 - Efficiency	97	M	Advanced Gas Water Heater
1 - Efficiency	121	M	Low-Cost, Low NOx, 100% Premixed Natural Draft Water Heater Burner
1 - Efficiency	158	M	Grease Control in Kitchen Ventilation Systems
1 - Efficiency	180	M	condensing sidearm water heater
1 - Efficiency	192	M	Smart Technology-Communication Interface
1 - Efficiency	208	M	Enhanced web-based analysis tool to reduce residential natural gas use
1 - Efficiency	75	M	Ultra-Clean Residential and Commercial Space Heaters
1 - Efficiency	151	M	Life-Cycle Cost and Energy Modeling of Home Water Heating Systems
1 - Efficiency	169	M	Gas Engine Refrigeration
1 - Efficiency	42	M	High Efficiency Engine Systems through Waste Heat Utilization
1 - Efficiency	70	M	Gas Fired Agricultural/Industrial Dryer Heat Pump

1 - Efficiency	66	M	High Air Preheat Low Emissions Heat Recovery Burner
1 - Efficiency	81	M	Repowering of California Utility Boiler Plants
1 - Efficiency	91	M	Industrial Plant Air-Makeup and Space Heating Efficiency
1 - Efficiency	110	M	Energy and Water Recovery from Flue Gas Using Nanoporous Membrane Tech
1 - Efficiency	132	M	Development of TCR with Process System-Waste Heat Recovery
1 - Efficiency	160	L	Demand Control Ventilation in Kitchen Hoods
1 - Efficiency	6	L	High Performance Compact Integrated Appliance
1 - Efficiency	7	L	Heating Only Gas-Fired Heat Pump
1 - Efficiency	19	L	A Desiccant-Assisted Evaporative Cooler for Commercial Buildings
1 - Efficiency	64	L	High Efficiency Gas Fired Radiant Burner
1 - Efficiency	65	L	High Efficiency Gas Engine Driven Heat Pump
1 - Efficiency	77	L	Design of an Energy-efficiency Incentive Program
1 - Efficiency	90	L	Small-Scale Solar Combined Heat and Power Demonstration
1 - Efficiency	98	L	Gas Engine-Driven Combination Heat Pump and Standby Generator
1 - Efficiency	112	L	Net Zero Peak Electric Building Energy System
1 - Efficiency	122	L	Minimum Effort Tight Duct System
1 - Efficiency	124	L	Low Cost - No Cost Therm Reduction
1 - Efficiency	128	L	Natural Gas Energy Efficiency for Seniors in Older Homes
1 - Efficiency	154	L	Combined Electrical, Heat & Cooling Generation Onsite
1 - Efficiency	176	L	Hybrid HVAC Cooling Plant
1 - Efficiency	205	L	Passive Energy Flue Dampers
1 - Efficiency	67	L	Low NOx Waterheater Burner
1 - Efficiency	93	L	CARB CHP Building Efficiency Assessment.
1 - Efficiency	172	L	Strategies for Energy-Efficient Natural Gas Technology RD&D Projects
1 - Efficiency	170	L	Optimal Energy and Water Systems for Car Washes
1 - Efficiency	46	L	Synergistic Efficiency & Emissions Enhancements for Industrial Heating
1 - Efficiency	104	L	Ultra-Efficient Hydronic Heating Systems
1 - Efficiency	105	L	High Efficiency Low NOx Immersion Fluid Heater
1 - Efficiency	114	L	Power Generation from Waste Energy – Advanced Cycles
1 - Efficiency	117	L	Model Community District Energy System – Research & Design
1 - Efficiency	25	L	Intrinsically Safe Gas Sensor
1 - Efficiency	34	L	Natural Gas Pump Using Water Agency Efficiency Improvements
1 - Efficiency	59	L	Conic Threaded Fasteners
1 - Efficiency	62	L	Conic Threaded Valve
1 - Efficiency	76	L	Low Emission Burners for Secondary Heating Applications
1 - Efficiency	111	L	Natural Gas Heating-Value Sensor
1 - Efficiency	126	L	Nanotechnology gas flow sensor based flowmeters
1 - Efficiency	166	L	Smart system diagnostic, monitoring & controls of emission-ProcessHtrs
1 - Efficiency	168	L	Gas Engine Air Compression
1 - Efficiency	171	L	Advanced Usage of Syn Gas Reactions In Direct Fuel Cell Cycles

1 - Efficiency	174	L	Power Generation from Waste Energy – Catalytic Microturbine
1 - Efficiency	175	L	Hybrid HVAC with TES
1 - Efficiency	179	L	Certified Low-Emission High-Efficiency CNG Industrial Truck Engine
1 - Efficiency	109	L	Low NOx Residential Gas Water Heater Operational Durability Program
1 - Efficiency	139	L	Production of Nanoparticles by the Natural Gas Industry: Current Status
2 - Environmental	188	H	Natural Gas Impurities – Impact on Appliances and Equipment
2 - Environmental	36	H	Gas Interchangeability-Impacts of Alt. Gas Supplies on Gas Appliances
2 - Environmental	72	H	Climate change impacts on energy generation and demand
2 - Environmental	80	H	California Residential IAQ Study Update
2 - Environmental	120	H	Public health benefits of natural gas emissions reductions
2 - Environmental	134	H	Sequestration of CO2 Emissions through Biocatalytic Mineralization
2 - Environmental	137	H	Identifying the Sources of Methane Emissions through Environmental For
2 - Environmental	138	H	Effects of Microbial Activities on the Integrity of Plastic Pipes: LNG
2 - Environmental	149	H	LNG Interchangeability for Power Generation Boilers
2 - Environmental	187	H	Increased PCB Mobilization in Transmission and Distribution Pipelines
2 - Environmental	204	H	Modeling Air Quality Consequences of Natural Gas Energy Generation
2 - Environmental	30	M	"Effects of Fuel Gas Composition for Natural Gas Engines"
2 - Environmental	40	M	Feasibility of CO2 as Cushion Gas for Natural Gas Storage
2 - Environmental	107	M	In-Situ NOx and O2 Sensors
2 - Environmental	135	M	Chemical CO2 Mitigation of Natural-Gas-Fired Power Plants
2 - Environmental	185	M	Pipeline Right-of-Way (ROW) Environmental Management
2 - Environmental	189	M	Infiltration and Ventilation Interactions with Gas Appliance Venting
2 - Environmental	157	M	Low-Cost Reduction of Biofouling at Gas-Fired Power Plants
2 - Environmental	164	M	Locating and Characterizing Outdoor Natural Gas Leaks
2 - Environmental	23	L	Radiation Fog, Lower Temperatures, and Natural Gas Use in Central CA
2 - Environmental	74	L	Nanotechnology Based Sensors
2 - Environmental	92	L	Best Practices to Assist Utilities in Reducing Emissions of Natural Ga
2 - Environmental	136	L	GIS-based Field Notification of Protected Wetlands/Endangered Habitats
2 - Environmental	143	L	Semiconducting Metal-Oxide Microsensors for Emission Monitoring
2 - Environmental	148	L	Future Foreign Pollution: Impact on Nat. Gas & Air-Quality in Calif.
2 - Environmental	181	L	Accommodating Varying Gas Chemistries from Non-Traditional Gas Supplie
2 - Environmental	156	L	Reduction in Infrastructure Requirements for Large House Developments
3 - Transportation	147	H	High Compression Spark Ignition System
3 - Transportation	115	H	Non-Destructive Evaluation and Monitoring of Composite

			Pressure Vessel
3 - Transportation	167	M	System Diagnostic, Monitoring & Controls of Emissions from IC Engines
3 - Transportation	9	L	Natural Gas Powered Steam/Gas-Electric Locomotive
3 - Transportation	10	L	Natural Gas Powered Steam/Gas-Electric Truck/Tractor
3 - Transportation	11	L	Natural Gas Powered Dual Fuel Diesel-Electric Locomotive
3 - Transportation	12	L	Natural Gas Powered Steam/Gas-Electric Tug Boat Propulsion System
3 - Transportation	27	L	Hydrogen from Coal and Sunshine
3 - Transportation	52	L	Comprehensive Roadmap for transformation to Clean City with NGVs
3 - Transportation	83	L	LNG Retrofit system for Diesel to LNG Lean Burn System
3 - Transportation	96	L	Distributed Production of Hydrogen
3 - Transportation	101	L	Hydrogen Fueling Station Development and Demonstration
4 - Renewables	4	H	Bay Island Biodiesel Pilot Project
4 - Renewables	21	H	Cost Effective Landfill Gas To LNG Processing Technology
4 - Renewables	38	H	Compressed Air Energy Storage and Enhanced Gas Recovery:
4 - Renewables	116	H	Renewable Methane Recovery and Utilization
4 - Renewables	125	H	BioMethane to Gasoline and Chemicals
4 - Renewables	152	H	Natural-Gas-Assisted Cyclic Catalytic Autothermal Reforming of Biomass
4 - Renewables	173	H	Sustainable Community Strategies, Santa Monica Demonstration Project
4 - Renewables	201	H	Feasibility of Landfill Gas Utilization in the Natural Gas Grid
4 - Renewables	2	M	Natural gas replacement/synthesis using waste gasification
4 - Renewables	14	M	Printed Photovoltaic Roofing Material
4 - Renewables	26	M	Bio-Hydrogen from wood waste with mixed culture of microorganisms
4 - Renewables	33	M	Aggregated Methane Production at Concentrated Animal Feeding Operation
4 - Renewables	37	M	Environmental/Economic Impacts from CHP and Digesters at Hog Farms
4 - Renewables	95	M	Solar Chiller - Renewable Energy Project
4 - Renewables	129	M	Environmental/Economic Impacts from CHP at Landfills
4 - Renewables	8	L	Pendulating Gravity Sail Prototype Development Project
4 - Renewables	13	L	Stationary Photovoltaic Modules with Parabolic-Prismatic Concentrators
4 - Renewables	45	L	Renewables in Commercial, Institutional and Industrial Markets
4 - Renewables	51	L	Natural Gas as a Bridge to Hydrogen Sourced Energy Solutions
4 - Renewables	54	L	Development and Application of a New Wind Energy Forecast System
4 - Renewables	71	L	Solar Thermal Energy Alternative to Natural Gas
4 - Renewables	194	L	Fast, Moderate Temperature Waste Gasification
5 - Strategic analysis	16	H	California-Mexico Natural Gas Issues
5 - Strategic analysis	49	H	Gas-Electric Industry Coordination and Reliability Enhancement
5 - Strategic analysis	82	H	LNG Terminal Hydrogen Production/Liquefaction Integration
5 - Strategic analysis	103	H	Low-Cost Real-Time Hydrocarbon Dew Point Measurement Tool



5 - Strategic analysis	127	H	Increasing Underground Gas Storage Capacity Using Hydrate Technology
5 - Strategic analysis	145	H	Impact Natural Gas Supply Disruptions on Electric and Gas Consumers
5 - Strategic analysis	163	H	Gas Market and Infrastructure Implications of Gas Availability
5 - Strategic analysis	195	H	Maximum Safe Loads On Buried Pipelines
5 - Strategic analysis	197	H	Mitigating the effects of Landslides on Gas Transmission Lines
5 - Strategic analysis	44	H	LNG Terminal Safety & Security Study
5 - Strategic analysis	146	H	Valuation of Natural Gas Storage for Public Policy
5 - Strategic analysis	41	M	California
5 - Strategic analysis	53	M	Outlook For LNG: A Global Assessment
5 - Strategic analysis	118	M	Natural Gas Quality Requirements and Tradeoffs
5 - Strategic analysis	119	M	Benefits Assessment & Verification Contractor for the Gas R&D Program
5 - Strategic analysis	141	M	Impact of California Market Structure on Natural Gas Usage
5 - Strategic analysis	142	M	Changing Gas Compositions in Western Gas Grid
5 - Strategic analysis	144	M	Impact of Efficiency and Renewables on Natural Gas Prices
5 - Strategic analysis	150	M	Collaborate Strategic Plan to Foster Renewable & Efficiency Investment
5 - Strategic analysis	159	M	Gas Treatment Options for Sensitive Customers
5 - Strategic analysis	177	M	Reduction of Lost and Unaccounted for Gas Volumes
5 - Strategic analysis	193	M	Natural gas price dynamics and forecasting models
5 - Strategic analysis	178	M	Accommodating Liquefied Natural Gas (LNG)
5 - Strategic analysis	35	L	Gas Supply Strategic Plan and Collaborative Assessment
5 - Strategic analysis	48	L	Dimethyl Ether Alternative Fuel
5 - Strategic analysis	50	L	Off-Peak Electricity Storage for Peak-Demand D.G. Applications
5 - Strategic analysis	57	L	Catastrophic Earthquake Risk Analysis and Remediation
5 - Strategic analysis	68	L	Modelling Natural Gas Systems in Various Power Generation Scenarios
5 - Strategic analysis	130	L	Real-Time XRF Nanotool for Underground Gas Storage Well Bores Integrity
5 - Strategic analysis	161	L	Combined Heat and Power Market Impacts on Gas and Electric Pricing
5 - Strategic analysis	184	L	Gas Transmission Measurement Equipment Operating Range Expansion
5 - Strategic analysis	61	L	Conic Pipe Threads
5 - Strategic analysis	198	L	Advanced Production of LNG from Natural Gas
6 - Advanced Generation	183	H	Laser Ignition System Demonstration for Natural Gas Pipeline Engines
6 - Advanced Generation	196	H	Advanced Cycle-Resolved Engine Controls
6 - Advanced Generation	15	H	Absorption Power and Refrigeration Cycle
6 - Advanced Generation	17	H	Ultra-Low NOx Duct Burner for Natural Gas-Fired CHP Turbines
6 - Advanced Generation	55	H	Chemical recuperation of natural gas feed for gas turbines
6 - Advanced Generation	94	H	Co-Production of Hydrogen and Electricity from Natural Gas
6 - Advanced Generation	102	H	High-Temperature Proton Exchange Membrane (PEM) Technology Development
6 - Advanced Generation	28	M	Demonstration of High Efficiency Natural Gas CHP Systems in California
6 - Advanced Generation	78	M	Low-emission Fuel-flexible Burner for Natural Gas and

Renewable Fuels			
6 - Advanced Generation	79	M	An Integrated, Low-CO2 Emission Power Plant for California
6 - Advanced Generation	86	M	Dual-output gas turbine engine
6 - Advanced Generation	140	M	On Line Chemical Reactive Control of HCCI Engines
6 - Advanced Generation	182	M	Communication Systems for Coordination of DG and Gas Delivery
6 - Advanced Generation	186	M	Chemical Synthesis from Natural Gas
6 - Advanced Generation	191	M	Wind, Hydrogen, Natural Gas Hybrid System
6 - Advanced Generation	199	M	Quantifying the net benefits of distributed generation
6 - Advanced Generation	203	M	Advanced Residential CHP Systems
6 - Advanced Generation	18	M	Ultra-Low NOx Gas Turbine Combustion System for Landfill Applications
6 - Advanced Generation	31	M	Ignition System Development for High BMEP Natural Gas Engines
6 - Advanced Generation	43	M	Aftertreatment Technologies for Lean Burn Natural Gas Engines
6 - Advanced Generation	88	M	Cool Flame Methane Reformation
6 - Advanced Generation	123	M	Enhancing Power Generation Efficiency with Concomitant CO2 Capture
6 - Advanced Generation	131	M	High Efficiency Commercially Viable Solid Oxide Fuel Cells
6 - Advanced Generation	155	M	Pulsed Reburning for NOx Control
6 - Advanced Generation	63	L	Efficient and Ultra Low Emissions Supplemental Firing Burner for CHP
6 - Advanced Generation	1	L	A NEW CLASS OF ARICES MINIMIZING ENGINE EMISSIONS & sfc
6 - Advanced Generation	20	L	Coal Gasification
6 - Advanced Generation	24	L	Infrared Biogas Sensor
6 - Advanced Generation	58	L	The new compact external combustion engine
6 - Advanced Generation	85	L	Advanced Usage of Syn Gas Reactions for Direct Electricity Generation
6 - Advanced Generation	206	L	Use of natural gas in propane reforming for fuel cell application.
6 - Advanced Generation	209	L	Closed Brayton Cycle Residential Energy Conservation System
6 - Advanced Generation	5	L	Renewable Biogas Solid Oxide Fuel Cell Development
6 - Advanced Generation	87	L	Catalyzed Combustion to improve natural gas combustion
6 - Advanced Generation	153	L	Integrated OxGen/Reforming Process for Producing H2 from Natural Gas

**Table A-2: Abstracts Rejected and Rationales**

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<b>ID #</b>	<b><i>Project Title</i></b>	<b><i>Rationale for Rejection</i></b>
3	Sitegen	Proposes research adequately addressed within the Distributed Energy Resources focus area of the PIER electricity program.
162	Hydrogen Technology Park	Proposes research addressing hydrogen as a transportation fuel. SB 76 states that natural gas research funds allocated to transportation shall not be used for the California Hydrogen Blueprint Plan.

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## **APPENDIX B: GAS R&D PROJECT ABSTRACT SUBMITTALS**

All of the 209 abstracts that were submitted are attached under separate cover (data CD) and can also be found at the Energy Commission's website:

[http://www.energy.ca.gov/naturalgas\\_research/documents/index.html](http://www.energy.ca.gov/naturalgas_research/documents/index.html)

# APPENDIX C: GAS R&D PROJECTS FUNDED IN THE 2005 PROGRAM YEAR

## Natural Gas Research Project Funding Summary: 2005 Plan

Contractor	Program Research Area	Plan	Actual
<b>Efficiency</b>		\$5,000,000	\$4,281,520
1 Gas Technology Institute	Flex Flame Burner For Aluminum Melting	\$360,000	
2 Gas Technology Institute	Field Demonstration of Prototype Super Boiler	\$240,000	
3 Pacific Gas & Electric Co.	Characterizing the Energy Efficiency Potential of Gas-fired Commercial Food Service Equipment	\$215,000	
4 Pacific Gas & Electric Co.	Characterizing the Potential of Gas-Fired Commercial Water Heating Equipment and Systems	\$320,000	
5 Pacific Gas & Electric Co.	Gas Cooling Scoping Study	\$129,000	
6 Gas Technology Institute	Efficient Commercial Gas Fryer for Food Service	\$357,835	
7 Gas Technology Institute	Next Generation Instantaneous Water Heater R&D	\$200,738	
8 Davis Energy Group	Super Efficient Gas Water Heating Appliance Initiative (SEGWHAI)	\$395,303	
9 Lawrence Berkeley National Labs	R&D for the 2008 Residential Energy Efficiency Standards and Recommendation on Improving Hot Water Equipment and Systems in CA homes	\$1,396,000	
10 Gas Technology Institute	"Transition" Project: Super Boiler: Phase I	\$397,563	
11 Gas Technology Institute	"Transition" Project: Development & Demonstration of Ultra- Low-NOx Burners	\$43,638	
12 CMC Engineering, Inc.	"Transition" Project: Power Generation Integrated Steam System	\$226,443	
Total Gas Efficiency Budget Re-allocation: \$-718480			
<b>Renewables</b>		\$2,000,000	\$1,300,000
13 Industrial Solar Technology	Development & Demonstration of medium to high temperature solar plant for food processing	\$700,000	
14 UC Merced	Development and testing of a low cost, high temperature solar collector system	\$600,000	
Total Renewables Budget Re-allocation: \$-700000			
<b>Environmental</b>		\$2,250,000	\$4,050,000
15 Gas Technology Institute	Emissions and Indoor and Outdoor Air Quality Impacts of Natural Gas Fuels and Fuel Blends on Combustion Sources	\$3,000,000	
16 University of California	Improved GHG Inventory methods for Landfill	\$400,000	
17 University of California	Development of a Model to Estimate Changes of the Shoreline in Northern California Under Different Sea Level Rise Scenarios	\$600,000	
18 Logan Energy Corp.	"Transition" Project: Fuel Cell Demonstration for Sust. Communities	\$50,000	
Total Environmental Budget Re-allocation: \$1800000			
<b>Strategic Analysis</b>		\$1,250,000	\$868,480
19 University of California	Research Opportunity Notice to develop new tools and models for natural gas storage	\$868,480	
Total Strategic Analysis Budget Re-allocation: \$-381520			
Total Projects:		\$10,500,000	\$10,500,000
Administration:		\$1,500,000	\$1,500,000
2005 Plan Budget:		\$12,000,000	
<b>2005 Obligated Funds:</b>			<b>\$12,000,000</b>